Domestic Animal Endocrinology 46 (2014) 1–11

Contents lists available at ScienceDirect

Domestic Animal Endocrinology

journal homepage: www.domesticanimalendo.com

Dietary selenium and nutritional plane alter specific aspects of maternal endocrine status during pregnancy and lactation

C.O. Lemley [a,†], A.M. Meyer [a,‡], T.L. Neville [a], D.M. Hallford [b], L.E. Camacho [a], K.R. Maddock-Carlin [a], T.A. Wilmoth [c], M.E. Wilson [c], G.A. Perry [d], D.A. Redmer [a], L.P. Reynolds [a], J.S. Caton [a], K.A. Vonnahme [a,*]

[a] Center for Nutrition and Pregnancy, Department of Animal Sciences, North Dakota State University, Fargo, North Dakota 58108
[b] Department of Animal and Range Sciences, New Mexico State University, Las Cruces, New Mexico 88003
[c] Division of Animal and Nutritional Sciences, West Virginia University, Morgantown, West Virginia, 26506
[d] Department of Animal Sciences, South Dakota State University, Brookings, South Dakota, 57007

ARTICLE INFO

Article history:
Received 24 July 2013
Received in revised form 13 September 2013
Accepted 15 September 2013

Keywords:
Endocrinology
Placenta
Pregnancy
Selenium
Sheep

ABSTRACT

Objectives were to examine effects of selenium (Se) supply and maternal nutritional plane during gestation on placental size at term and maternal endocrine profiles throughout gestation and early lactation. Ewe lambs (n = 84) were allocated to treatments that included Se supply of adequate Se (ASe; 11.5 μg/kg BW) or high Se (HSe; 77 μg/kg BW) initiated at breeding and nutritional plane of 60% (RES), 100% (CON), or 140% (EXC) of requirements beginning on day 40 of gestation. At parturition, lambs were removed from their dams, and ewes were transitioned to a common diet that met requirements of lactation. Blood samples were taken from a subset of ewes (n = 42) throughout gestation, during parturition, and throughout lactation to determine hormone concentrations. Cotyledon number was reduced ($P = 0.03$) in RES and EXC ewes compared with CON ewes. Placental delivery time tended ($P = 0.08$) to be shorter in HSe ewes than in ASe ewes, whereas placental delivery time was longer ($P = 0.02$) in RES ewes than in CON and EXC ewes. During gestation, maternal progesterone, estradiol-17β, and GH were increased ($P < 0.05$) in RES ewes and decreased ($P < 0.05$) in EXC ewes compared with CON ewes. In contrast, maternal cortisol, IGF-I, prolactin, triiodothyronine, and thyroxine were decreased in RES ewes and increased in EXC ewes compared with CON ewes during gestation. Selenium supply did not alter maternal hormone profiles during gestation. During parturition and lactation, maternal hormone concentrations were influenced by both Se and maternal nutritional plane. During the parturient process, HSe ewes tended to have greater ($P = 0.06$) concentrations of estradiol-17β than ASe ewes. Three hours after parturition a surge of GH was observed in ASe-RES ewes that was muted in HSe-RES ewes and not apparent in other ewes. Growth hormone area under the curve during the parturient process was increased ($P < 0.05$) in ASe-RES vs HSe-RES ewes. Ewes that were overfed during gestation had reduced ($P < 0.05$) estradiol-17β but greater IGF-I, triiodothyronine, and thyroxine ($P < 0.05$) compared with RES ewes. Even though ewes were transitioned to a common diet after parturition, endocrine status continued to be affected

* Corresponding author at: 181 Hultz Hall, Dept 7630 PO Box 6050, Fargo, ND 58108-6050, USA. Tel.: +1 701 231 5883; fax: +1 701 231 7590.
E-mail address: kim.vonnahme@ndsu.edu (K.A. Vonnahme).
† Present address: Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State, Mississippi 39762.
‡ Present address: Division of Animal Science, University of Missouri, Columbia, Missouri 65211.

http://dx.doi.org/10.1016/j.domaniend.2013.09.006

into lactation. Moreover, it appears that gestational diet may partially affect lactational performance through altered endocrine status.

1. Introduction

Several researchers have shown alterations in steroid, somatotropic axis, and thyroid hormones in animals fed above or below maintenance requirements during gestation [1–4]. Endocrine profiles during gestation have been associated with placental nutrient transport capacity in the ewe [5] and improvements in endocrine or metabolic or both profiles during nutritional stress may be directly implicated in fetal growth and subsequent offspring performance. In addition to altered nutrient partitioning to the uterus during late gestation, endocrine profiles, including steroids, prolactin, and GH, during gestation and lactation also affect proper mammary development and lactogenesis, which are vital for postnatal nutrition and development. In our experimental model, altered nutritional plane during gestation, followed by realimentation during lactation, affects colostrum and milk composition and yield in ewes [6,7]. Moreover, supranutritional selenium (Se) supplementation increased colostrum yield and milk yield in ewes [7]. Therefore, nutritional plane and Se supply may alter endocrine profiles during gestation, leading to changes in mammary development and preparation for the subsequent lactation. These endocrine effects could therefore directly cause alterations in postnatal growth and development irrespective of placental nutrient utilization during gestation. Despite this, there is a paucity of data to link gestational nutrition with gestational and lactational endocrine profiles and postpartum milk production, especially in the face of supranutritional Se.

The objectives of the present experiment were to determine placental size at term and maternal endocrine profiles during gestation, parturition, and lactation in undernourished or overnourished ewes, with or without supranutritional dietary Se, during gestation. We hypothesized that maternal placental characteristics and endocrine profiles would be altered by nutrient restriction or overnourishment, and that these changes would persist into early lactation even when ewes were fed to a common nutritional plane. In addition, we hypothesized that feeding a high-Se diet during gestation would affect placental and endocrine characteristics, resulting in the observed increases in fetal growth and milk production.

2. Materials and methods

2.1. Animals and diets

Institutional Animal Care and Use Committees at North Dakota State University, Fargo, and the USDA, Agricultural Research Service, US Sheep Experiment Station (Dubois, ID, USA) approved animal care and use for this study.

Ewes were bred and managed as described in Meyer et al [7,8]. Breeding occurred at the US Sheep Experiment Station, and at this time, Se treatments (adequate Se [ASe; 3.5 μg Se/kg of BW daily] or high Se [HSe; 65 μg Se/kg of BW daily]) were initiated. After transport to North Dakota State University on day 36 of gestation, pregnant Rambouillet ewe lambs (n = 84; 52.1 ± 6.2 kg) were individually housed. Ewes remained on their Se treatments (actual intakes: ASe, 11.5 μg Se/kg BW daily; HSe, 77.0 μg Se/kg BW daily), and on day 40 of gestation were assigned randomly to 1 of 3 nutritional plane treatments that supplied 60% (RES), 100% (CON), or 140% (EXC) of National Research Council [9] recommendations for 60-kg pregnant ewe lambs during mid to late gestation (weighted ADG of 140 g) except for Se. This resulted in a completely randomized design with a 2 × 3 factorial of Se supply × nutritional plane treatments (ASe-RES, ASe-CON, ASe-EXC, HSe-RES, HSe-CON, HSe-EXC; n = 14 per treatment). At parturition 42 ewes (7 per treatment) that gave birth to singleton lambs were selected to be mechanically milked twice daily for 20 d [7].

All diets were fed once daily in a complete pelleted form (based on wheat middlings, beet pulp, alfalfa meal, and ground corn). Three pellet formulations (ASe, HSe, and concentrated Se pellets; described in Meyer et al [8]) were blended to meet Se and ME intake according to the Se treatment and nutritional plane of each ewe. The ASe pellet contained 15.9% CP, 2.83 Mcal/kg ME, and 0.67 mg/kg Se (dry matter [DM] basis). Selenium-enriched wheat mill run was used to replace wheat middlings and corn in the basal diet to make a HSe pellet (6.13 mg/kg Se, 16.6% CP, 2.82 Mcal/kg ME; DM basis). Purified seleno-methionine was added to achieve 37.1 ppm Se in the concentrated Se pellet (16.2% CP, 3.01 Mcal/kg ME; DM basis). Every 14 d, BW was measured, and diets were adjusted accordingly. Both Se supply and nutritional plane treatments were terminated at parturition. Ewes (n = 42) that were assigned to necropsy on day 20 of lactation were transitioned to receive 100% of the National Research Council [9] requirements for early lactation, provided by the ASe pellet fed during gestation and a lactation protein supplement pellet [7]. A 5-d transition period was used to increase intake from the gestation level to lactation level, and feed was delivered after each milking (2 times a day).

All births were attended, and lambs were removed from their dams immediately after birth. After parturition, ewes were monitored closely until placentas were expelled, and time was recorded to calculate time elapsed from time of lambing to expelling of the placenta. At 3-h postpartum ewes received 1 mL of oxytocin (20 IU; AgriLabs, St. Joseph, MO, USA) to facilitate collection of colostrum; 34 ewes had not expelled placentas at the time of oxytocin administration. Placentas were stored in a sealed bag at 4°C until processing, at which time the placenta was weighed, and cotyledons were cut from the placenta, counted, and weighed. The intercotyledonary weight was considered to be the remaining weight of the placenta.

Endocrine patterns were determined in a subset of singleton-bearing ewes (n = 42) throughout gestation, parturition, and lactation. Blood samples were collected for both serum and plasma on days 39, 53, 67, 81, 95, 109, 123,